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A REVIEW OF COST ANALYSIS IN AGRICULTURAL UTILIZATION RESEARCH

At the Southern Utilization Research and Development Division

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

	Page
Introduction	1
Nature and Variety of Cost Work	2
Cost research on chemically modified cottons	2
Partial acetylation	3
Full acetylation	4
Padding-curing finishes	5
Aminization	6
THPC-MF resin treatment	6
Carbamoylethylation	6
Phosphonomethylation	6
APO resin treatment	6
APO-THPC resin treatment	6
Formic acid colloid of methylolmelamine	7
Carboxymethylation	7
Hydroxyethylation	8
Cyanoethylation	8
Wash-wear	8
Agricultural oil products and derivatives	9
Gossypol	9
Cocoa butterlike fat	11
Tung oil-resin varnish vehicle	11
Filtration-extraction	12
Summary	13
Literature cited	15

A REVIEW OF COST ANALYSIS IN AGRICULTURAL UTILIZATION RESEARCH AT THE SOUTHERN UTILIZATION RESEARCH AND DEVELOPMENT DIVISION [1]

by

K. M. Decossas, E. F. Pollard, and E. L. Patton [2]

ABSTRACT

An integral part of the utilization research investigations at the Southern Utilization Research and Development Division of the U. S. Agricultural Research Service is the determination of the cost of producing products by new and improved processes from cotton, cottonseed, peanuts, tung, rice, fruits, vegetables, sugarcane, and naval stores.

This paper is a review of recent cost work at the Southern Utilization Research and Development Division. The nature and variety of cost estimation, its usefulness in planning and evaluation of research, and its importance in process and product development, and commercialization are described.

New low-cost processes have been developed for converting cotton into textile products having improved flame-, heat-, mildew-, rot-, soil-, weather-, and wrinkle-resistance, water repellency, increased breaking strength and elongation, dyeability, solubility, reactivity, ion-exchange, and other improved properties. The paper includes a review of several of these new cotton chemical processes, estimates of their costs, and the status of their commercialization. A number of these processes can be accomplished in conventional textile finishing equipment, and are particularly suited for intermittent production in equipment already available in finishing plants. The various estimated costs show that these chemical processings of cotton can be inexpensive. Partial acetylation, carboxymethylation, APO-THPC resin finishing, THPC-Methylolmelamine resin finishing, and wash-wear finishing have been adopted commercially. The formic acid colloid process is approaching commercialization.

New derivatives of cottonseed, rice, and tung show promise as low-cost products of high quality. These are cocoa butterlike fat, tung oil-resin varnish vehicle, cottonseed oil and meal, and rice bran wax from filtration-extraction. Of these, filtration-extracted oil and meal and tung oil-resin varnish vehicle are being produced commercially.

INTRODUCTION

An integral part of the utilization research investigations at the Southern Utilization Research and Development Division of the U. S. Agricultural Research Service is the determination of the cost of producing products by new and improved processes from cotton, cottonseed, peanuts, tung, rice, fruits, vegetables, sugarcane, and naval stores.

This paper is a review of recent cost work at the Southern Utilization Research and Development Division. The nature and variety of cost estimation, its usefulness in planning and evaluation of research, and its importance in process and product development, and commercialization are described.

[1] Presented at the Southwest Regional Meeting of the American Chemical Society, Baton Rouge, Louisiana, December 3-5, 1959.

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NATURE AND VARIETY OF COST WORK

Cost estimates are made during every phase of research and can be classified as "armchair," preliminary, revised, and final cost estimates. This is illustrated in Figure 1. "Armchair"

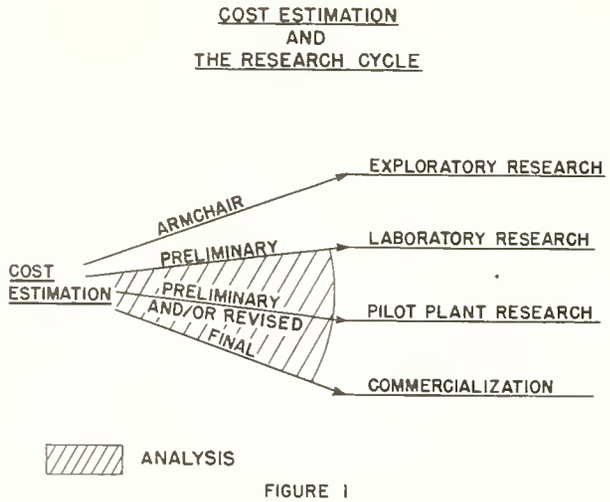


FIGURE 1

cost estimates are made preferably after limited exploratory research has been done, and they are useful to research planners in considering the economic feasibility of research proposals and line projects. In "armchair" estimates, similarities with commercial processes are used to a maximum extent in estimating both equipment and operating costs. Higher cost estimation factors are employed than in the subsequent more detailed estimates, to allow for possible process changes and unforeseeable expense.

As research progresses, preliminary cost studies of proposed processes are made prior to, during, and/or at the completion of pilot plant work, complementing the Southern Division's over all engineering and development program. These estimates identify items of greatest cost and are used by project leaders in furthering process and product development. They are also used by our cost engineers who suggest less expensive alternatives. Preliminary cost estimates include a consideration of equipment costs, other capital requirements, and processing costs. Later, the preliminary cost estimates are revised during pilot plant development as process modifications are made.

In preparing preliminary cost estimates, flow sheets and material balances are developed from laboratory, pilot plant, and related commercial data, and equipment costs are obtained from equipment manufacturers. Allowance is made for installation, piping, instrumentation, auxiliaries, engineering and construction, and contingencies, using accepted standard chemical and cost references (3, 11, 48, 69)[3]. Operating costs, such as chemicals, labor, utilities, supervision, maintenance, and others are estimated, based on prevailing prices, labor and utility rates, and established cost estimation factors for the type of process involved. Other costs, such as packaging, control laboratory, payroll and general plant overhead, insurance, property taxes, depreciation, financing, and sales are also included.

Final cost studies, based largely on commercial operations, are made early during commercialization. These costs are useful in advancing the commercialization of the more profitable processes, and in evaluating the impact of research on industry, as a part of program evaluation at the Southern Division.

Cost analysis is begun on completion of a preliminary cost study and usually continues until a final cost study has been completed. In cost analysis, detailed processing techniques are analyzed to determine how costs may be reduced. Consideration is given to possible equipment economies, process improvements, production rate increases, use of less expensive chemicals, lower degrees of substitution, recovery of chemicals, and possible reduction of chemical prices, including price projections by manufacturers.

Cost studies and analyses of the types mentioned have been made principally for producing chemical cottons and oilseed derivatives.

COST RESEARCH ON CHEMICALLY MODIFIED COTTONS

The history, progress, and current status of the chemical modification of cotton were discussed recently by Fisher and Perkerson (27). The successful use of chemicals to impart durable, significant changes to cotton is a development of this century. And at the Southern Laboratory, scientists and engineers have developed new chemical processes for transform-

[3] Figures in parentheses refer to Literature Cited at end of this paper.

ing cotton into chemical cottons possessing useful and valuable properties (26). The following paragraphs are a review of several of these new cotton chemical processes, estimates of their costs, the status of their commercialization, and the improved and special properties of the cotton products.

Partial Acetylation (1, 4, 8, 9, 14, 31, 40). Processes for the partial acetylation of cotton yarn and fabric were developed. This chemically modified cotton product has outstanding resistance to deterioration by micro-organisms and heat, and has been found to have unusually long service life in such applications as commercial laundry press cloths, household ironing board covers, water softener bags, and sandbags.

The SURDD process for the continuous partial acetylation of cotton yarn and fabric is shown in Figure 2 and consists of pretreating or activating cotton for 2 minutes at 180° F. in a bath of glacial acetic acid containing sufficient acetic anhydride to combine with the normal moisture regain of cotton; impregnating it for 1 minute with perchloric acid catalyst in a bath containing 5 to 6 percent of perchloric acid catalyst dissolved in glacial acetic acid; and reacting it for 3 minutes at 68° F. in a solution containing 40 percent acetic anhydride and 60 percent acetic acid. These are followed by catalyst inactivation with potassium acetate, and subsequent washing and drying.

Preliminary cost estimates (29) and a cost analysis (18), based on batch and continuous operations in hypothetical plants, show that cotton raw stock can be partially acetylated in a package dye machine to 15 percent acetyl content for as little as 38.7 cents per pound

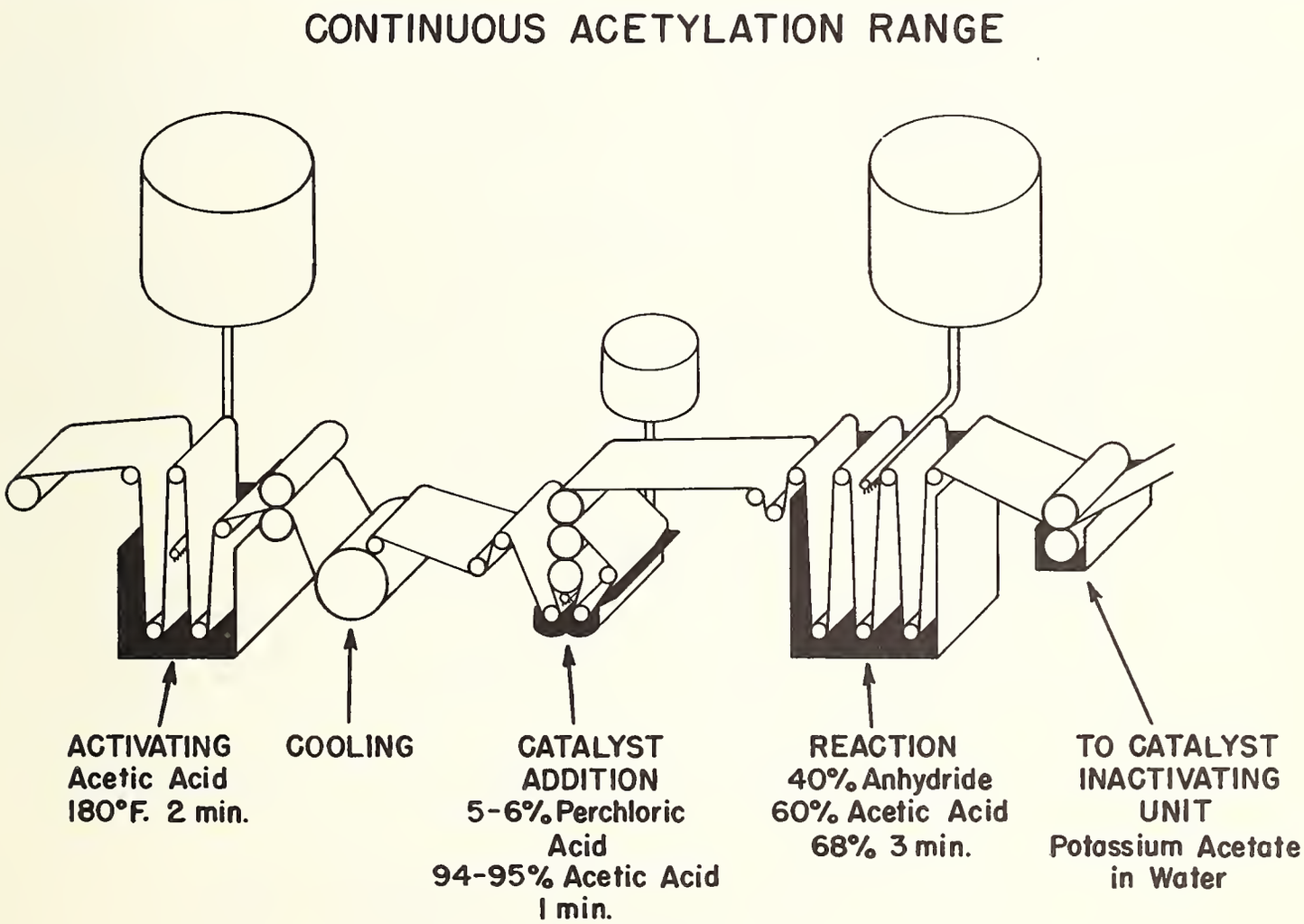


FIGURE 2

of product; that yarn processing costs range from $1.18 per pound of product down to 14.2 cents per pound as production is increased from 34,000 pounds annually in a package dye machine to 61.5 million pounds annually in a continuous acetylation range; and that fabric processing costs for 48 x 48, 60" wide, 8 oz. sheeting range from 51.6 cents per pound of product down to 16.7 cents per pound as production is increased from 250,000 yards annually in dye jigs to 12.1 million yards annually in a continuous acetylation range.

PA cotton is now being produced commercially in the United States and England. These estimated costs along with others obtained from commercial processors were used by the Task Group on Selected Chemically Modified Cottons and Agricultural Marketing Service at the Southern Laboratory in preparing cost-performance data for PA cotton and in estimating its market potential (6). It was found that the cost-performance ratio of PA cotton to competitive materials in commercial laundries ranges from 1:2.27 in competition with nylon in flatwork iron roll padding, to 1:1.28 in competition with stainless steel wool in press padding. The potential market for PA cotton for commercial laundries was estimated to run from 9,800 to 27,100 PA cotton bale equivalents, depending upon the assumed market penetration. This total market amounts to an estimated 40,000 PA cotton bale equivalents. The home ironing-board cover market potential for PA cotton was estimated at about 2,225 PA cotton bale equivalents annually.

Full Acetylation (10). Highly acetylated cotton, usually referred to as FA cotton has excellent electrical insulating properties, rot resistance, heat resistance, flat abrasion resistance, some thermoplasticity, and is dyeable with acetate colors. In this process, illustrated in Figure 3, fabric is presoaked for 1 hour in a 99 percent acetic acid-1 percent water solution at room temperature; reacted for 4 hours in a solution of acetic anhydride, isopropyl acetate, and acetic acid at 58° F. in the presence of perchloric acid catalyst; washed in warm water and dried. It was determined that the processing costs for producing a FA fabric product having an acetyl content of 35 percent, or a Degree of Substitution of 2.0, is from $1.30 per pound of product at an annual production

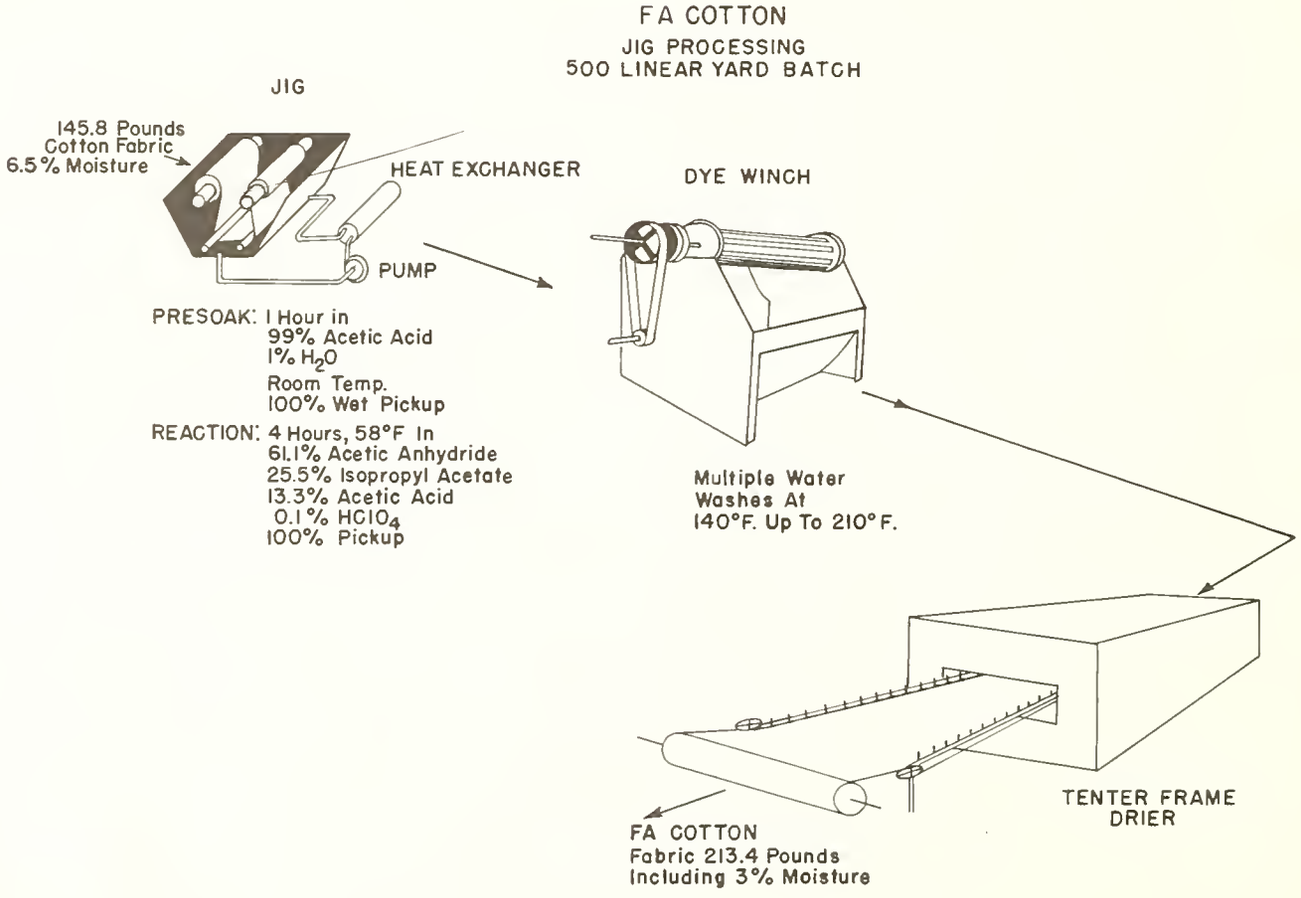


FIGURE 3

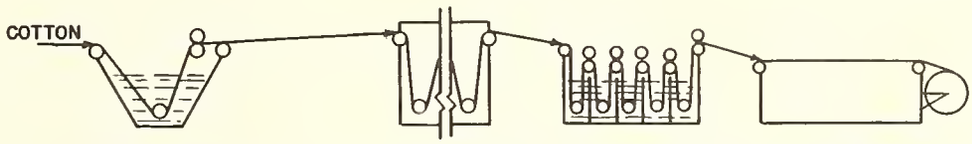
of 53,400 pounds of FA product to 66.3 cents at a production of 900,000 pounds of FA product (44). These costs do not include the cost of the untreated cotton fabric.

FA cotton yarns and cloths, differing in method of preparation and in certain properties, have been prepared in England since 1936, and are sold under the name Crestic. Up until now they have been sold exclusively to the electrical industry because of their outstanding insulating properties.

Padding-Curing Finishes.

A number of chemical cottons have been prepared by padding of cotton fabric through chemicals, drying and curing at elevated temperatures, washing the cotton free of unreacted chemicals and byproducts, and final drying of the product. The processes involving this sequence of operations are shown in Figure 4.

PADDING — CURING FINISHES



PROCESS	PADDER: TREATMENT SOLUTION	PADDER: PICK-UP	DRYING – CURING OVEN	WASHER	TENTER FRAME
AMINIZATION	20% 2-AES 30% NaOH 0.5% WETTING AGENT 49.5% H_2O	140%	DRYING AND CURING 5 MIN AT 285°F	WASHING SOURING & NEUTRALIZATION	FINAL DRYING
THPC-MF	15.8% THPC 9.5% TRIMETHYLOL-MELAMINE 9.9% UREA 3.0% TEA 61.8% H_2O	70%	DRYING 2 MIN. AT 185°F CURING 4 MIN AT 285°F	WASHING & SOFTENING	FINAL DRYING
CARBAMOYLETHYLATION	50% ACRYLAMIDE 4% NaOH 46% H_2O	90%	DRYING & CURING 4 MIN. AT 275°F	WASHING & SOURING	FINAL DRYING
PHOSPHONOMETHYLATION	3.9% CMPA 27.4% NaOH 68.7% H_2O	150%	DRYING & CURING 5 MIN. AT 285°F	WASHING	FINAL DRYING
APO RESIN	12% APO 2% $Zn(BF_4)_2$ 1% WETTING AGENT 85% H_2O	80%	DRYING 4 MIN. AT 185°F CURING 4 MIN. AT 285°F	WASHING & SOFTENING	FINAL DRYING
APO-THPC RESIN	13.1% THPC 11.9% APO 3.3% TEA 0.8% WETTING AGENT 70.9% H_2O	65%	DRYING 4 MIN. AT 185°F CURING 4 MIN. AT 285°F	WASHING & SOFTENING	FINAL DRYING
FORMIC ACID COLLOID (WRINKLE RESISTANCE)	11.9% FORMIC ACID 10.3% TRIMETHYLOL-MELAMINE 77.8% H_2O	80%	DRYING 2 MIN. AT 175°F CURING 4 MIN. AT 285°F	WASHING	FINAL DRYING
FORMIC ACID COLLOID (ROT AND OUTDOOR WEATHERING)	20% FORMIC ACID 17% TRIMETHYLOL-MELAMINE 63% H_2O	80%	DRYING 2 MIN. AT 175°F CURING 4 MIN. AT 285°F	WASHING	FINAL DRYING

LEGEND

2-AES	2 AMINOETHYLSULFURIC ACID	TEA	TRIETHANOLAMINE
THPC	TETRAKIS (HYDROXYMETHYL) PHOSPHONIUM CHLORIDE	CMPA	CHLOROMETHYLPHOSPHONIC ACID
APO	TRIS (2-AZIRIDINYL) PHOSPHINE OXIDE	MF	TRIMETHYLOLMELAMINE

FIGURE 4

Aminization (34, 35, 55, 57). The cotton fabric is padded through an aqueous solution of sodium hydroxide and 2-amino-ethylsulfuric acid, dried and cured for 5 minutes at 285° F., water-washed, soured in a 1 percent acetic acid solution, neutralized in a one-half percent ammonium hydroxide solution, and dried on a tenter frame.

The product has good ion exchange capacity, has a high affinity for acid dyes, and has enhanced reactivity that lends itself to further modification to impart flame resistance, rot resistance, water repellency, and other useful properties of cotton. A processing cost as low as 20.4 cents per pound of product has been estimated for a product containing 0.6 percent nitrogen.

THPC[4]-MF Resin Treatment (36, 56). This process for imparting flame resistance to cotton has created widespread interest in the textile finishing field. Cotton fabric is padded through an aqueous solution of THPC, methylolmelamine, urea, and triethanolamine, dried for 2 minutes at 185° F., cured for 4 minutes at 285° F., hot-water washed for 2 minutes at 180° F., and dried. This process is being used by Proban Ltd. in England, and has been used also in the United States. This treatment can be applied satisfactorily to cotton fabrics weighing 8 ounces per square yard or more. The resin treatment needed to impart the required degree of flame resistance has been estimated to cost as little as 15 cents per pound of product, based on a reasonable projected price of 70 cents per pound of THPC (45).

Carbamoylethylation (28). This process consists of padding cotton through a solution containing, on a weight basis, 50 percent acrylamide, 4 percent sodium hydroxide, and 46 percent water; followed by reaction in an oven at 275° F. for 4 minutes, after which the fabric is washed with water and dried. The product, containing 2.39 percent nitrogen, has substantial heat resistance, a slight degree of rot resistance and good retention of strip breaking strength. The cost study showed that cotton can be carbamoylethylated at a cost of 16.4 cents per pound of product (19).

Phosphonomethylation (24). In this process, a cotton fabric having good flame resistance is obtained by padding through a solution containing 3.9 percent chloromethylphosphonic acid, 27.4 percent caustic, and the remainder water; drying and curing at 285° F. for 5 minutes; water washing, including 1 percent ammonium hydroxide in the last wash; and drying. The degree of substitution can be varied widely by varying the concentration of the phosphonomethylating agent and of the sodium hydroxide, and by varying the time and temperature of the cure. When the phosphorus content is between 0.6 and 1.0 percent, good flame resistance is obtained. The cost of this treatment was estimated to be 14.7 cents per pound of product.

APO[5] Resin Treatment (23). A preliminary cost study has been made for this resin process which imparts wrinkle resistance and limited flame resistance to cotton fabrics. A treatment solution containing 12 percent APO solids, 2 percent zinc fluoroborate catalyst, 1 percent wetting agent, and water is used. After padding through the treatment solution, the fabric is dried for 4 minutes at 185° F., cured for 4 minutes at 285° F., water-washed, and dipped after final wash in a solution containing 1 percent softener. The softener used was of a type prepared from ethylene imine and an isocyanate. Using a current and projected APO price range of 30 cents per pound to $2.25 per pound, and a projected softener price of $2.00 per pound, processing costs for this resin treatment range from 8.2 to 28.2 cents per pound of product, at an annual production of 25 million pounds.

APO-THPC Resin Treatment (22, 54). With this process, there has been developed a new and improved flame retardant finish for cotton. The cotton is padded through an aqueous solution of APO, THPC, triethanolamine, and wetting agent, dried for 4 minutes at 185° F., cured for 4 minutes at 285° F., washed, and dried. With a relatively low resin add-on, this treatment yields a product having a very durable flame retardant finish, rot and mildew resistance, and excellent hand. Using a projected THPC price of 70 cents per pound, and projected prices for APO ranging from 30 cents to $2.25 per pound, costs for imparting the required degree of flame resistance to fabric varied from 28.6 cents down to 11.3 cents per

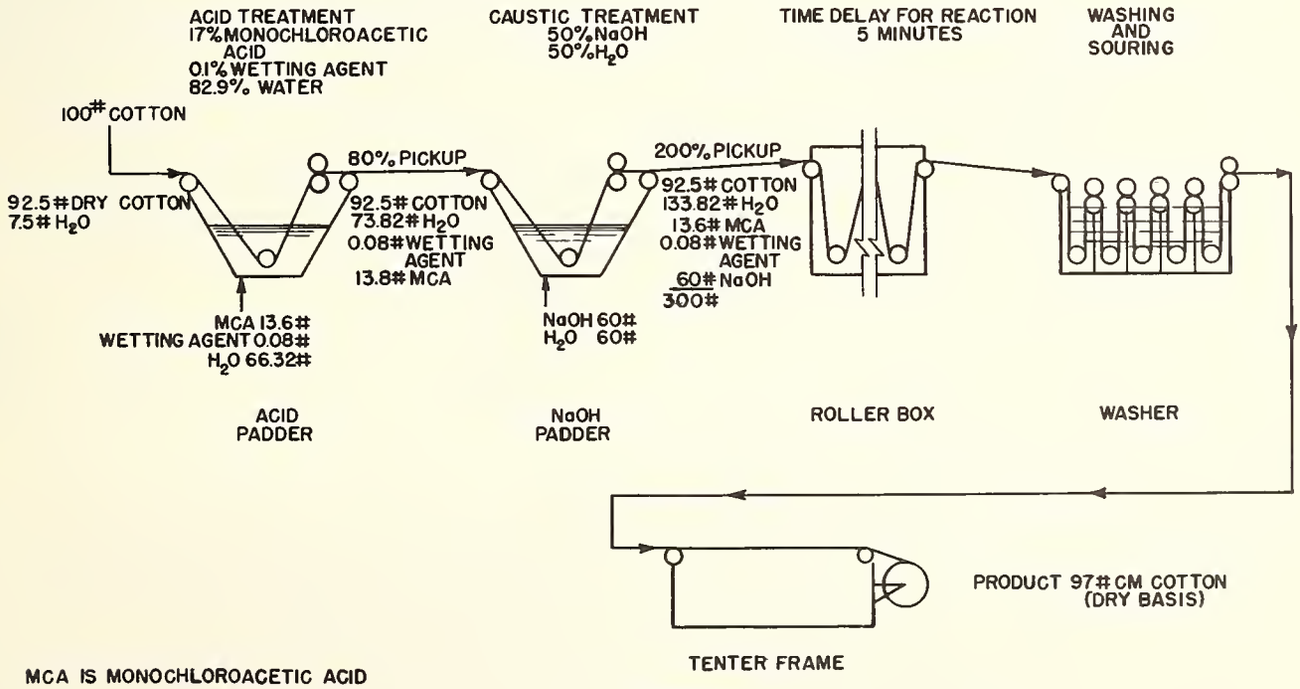
[4] Tetrakis (hydroxymethyl) phosphonium chloride.
[5] Tris (1-aziridinyl) phosphine oxide

pound of product at a processing rate of 120 yards per minute.

Formic Acid Colloid of Methylolmelamine (7). Weather- and rot-resistance can be imparted to cotton by padding the cotton through an aqueous solution of 17 percent trimethylolmelamine and 20 percent formic acid, drying for 2 minutes at 175° F., curing for 4 minutes at 285° F., washing with hot and cold water, and drying. For producing a wrinkle-resistant cotton fabric, an aqueous solution of 10.3 percent trimethylolmelamine and 11.9 percent formic acid is used. Costs for imparting weather- and rot-resistance were as low as 14.9 cents per pound of product, and for wrinkle-resistance as low as 10.8 cents per pound (43).

Carboxymethylation (15, 16, 58, 59, 63, 64). Cotton in the form of fiber, yarn, or cloth can be carboxymethylated by impregnation with monochloroacetic acid followed by treatment with strong sodium hydroxide. Two distinct types of products can be made, differing chemically only in the degree of carboxymethylation, but having vastly different physical properties. One product, having a degree of substitution less than 0.2 ether groups per anhydroglucose unit, is a cloth with properties considerably changed from those of cotton. Among these properties are: A built-in starched effect (15); increased moisture regain (16), water absorbency, and air permeability (58); increased breaking strength and elongation (15); changed dyeing characteristics, such as improved dyeing with azoics and an affinity for basic dyes (15); increased resistance to soiling from aqueous dispersions and greater ease of soil removal (15); cation exchange properties (15); high water swellability (58); built-in catalyst which will effect reaction of certain methylol resins with the modified cotton to produce wrinkle-resistance with good strength retention (15); and a greater receptivity to further treatment than ordinary cotton (64). The other product, having a degree of substitution greater than 0.33, is a water-soluble modified cotton, that dissolves upon contact with water or dilute alkali solution. Carboxymethylated cotton of this type is useful whenever a temporary, easily removable fiber is necessary. Lace and embroidery makers, shirt and sock manufacturers, upholsterers, fur blenders, and meat packers have shown interest in the soluble cotton products. Carboxymethylated cotton is now in production in one American plant and custom production on a commission basis is available. In the process of Figure 5, for producing insoluble carboxymethylated cotton with a degree of substitution of 0.1, the cloth is padded through an aqueous solution of 17 percent monochloroacetic acid containing a small amount of an anionic wetting agent; padded with a 50 percent solution of sodium hydroxide; reacted in a roller box for 5 min-

CONTINUOUS PARTIAL CARBOXYMETHYLATION OF COTTON FABRIC TO D.S. 0.1



MCA IS MONOCHLOROACETIC ACID

FIGURE 5

utes; followed by preliminary washing with cold and hot water, souring with dilute acetic acid solution, final washings with cold and hot water, and drying. The product is obtained as the sodium salt of carboxymethylcellulose after normal washing and souring but may be converted to the free carboxyl form by treatment with solutions of mineral acids. Total processing costs for carboxymethylating 80 square cotton print cloth, 52″ wide, 3.10 linear yards per pound of untreated fabric, into an insoluble product with a degree of substitution of 0.1, have been estimated to range from 9.9 cents per pound of product at an annual production of 25.2 million yards in hypothetical plants to 30.4 cents per pound at an annual production of 1.2 million yards (20).

Hydroxyethylation (42, 65, 67, 68). Hydroxyethylated cotton has a crisp hand, linen to parchmentized appearance, and enhanced reactivity and dyeability. The semi-continuous process, illustrated in Figure 6, consists of

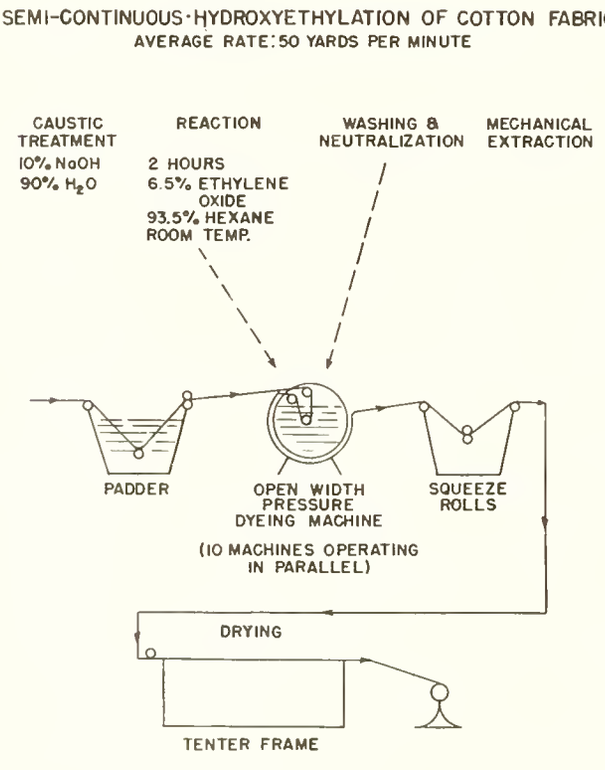


FIGURE 6

padding the cotton fabric through a 10 percent caustic solution, reacting the fabric for 2 hours at room temperature in a bath of 6.5 percent ethylene oxide and 93.5 percent hexane, followed by water washing at 140° F., neutralizing in dilute acetic acid, washing again, and drying. Costs for hydroxyethylating 80 square cotton print cloth, 60 inches wide, 2.6 yards per pound of untreated fabric, to 14.3 percent combined ethylene oxide, have been estimated to range from 16.3 cents per pound of product at an annual production of 25.2 million yards in hypothetical plants to 26.9 cents per pound at an annual production of 5.2 million yards.

Cyanoethylation (12, 13, 39). Cyanoethylated cotton, produced by the reaction of cotton with acrylonitrile, possesses permanent mildew resistance, greater heat resistance, and improved acid resistance and rot resistance. The continuous process for fabric (39) consists of padding the fabric with caustic solution, dipping in cold liquid acrylonitrile, reacting with acrylonitrile vapors, dipping in cold dilute phosporic acid, steam distilling to remove volatile acrylonitrile, washing, and drying. The continuous cyanoethylation of 60 inch, 4 oz. per square yard cotton fabric at an annual rate of 10,830,000 pounds has been estimated to cost 17.1 to 18.1 cents per pound. Technological advances in the manufacture of acrylonitrile (46, 49) will undoubtedly result in the availability of acrylonitrile soon at lower costs. Based on a reduced price of acrylonitrile, continuous cyanoethylation of fabric has been estimated to cost about 13.5 cents per pound of fabric treated.

Wash-Wear (38, 60, 61, 62). Cost estimates have been made for the cyclic ethylene urea-acrylate-silicone wash-wear resin treatment of cotton trousers using a batch method at the manufacturing level. The technique used is illustrated in Figure 7, and consists of soaking

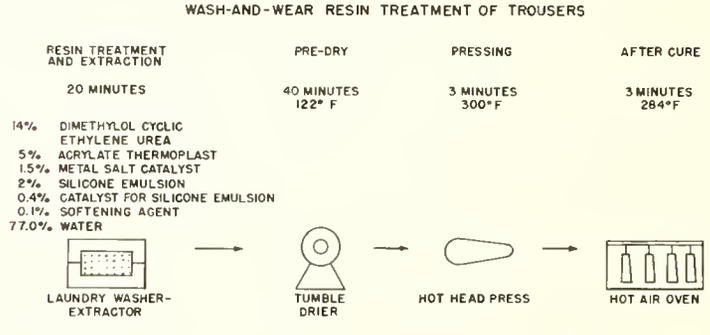


FIGURE 7

the trousers in an aqueous solution of 14 percent dimethylol cyclic ethylene urea, 5-percent acrylic emulsion, 2-percent silicone lubricant, catalysts, and a surface active agent; extracting the excess pickup by centrifugation;

predrying in a tumble dryer for 40 minutes at 122° F., pressing for 3 minutes at 300° F. on a hot head press, and after-curing for 3 minutes at 284° F. in a hot-air oven. The estimated finishing costs for the trousers made from 2.3 square yards of 2/2 twill cotton suiting weighing 4.7 ounces per square yard ranged from 20.4 cents per pair at an annual production of 2.6 million pairs to 33.6 cents per pair at an annual production of 250,000 pairs.

In a recent study (5) by an agricultural economist of Agricultural Marketing Service stationed at the Southern Laboratory, the importance of wash-wear apparel was measured in dollars and cents and in greater freedom from housework. One example cited was shirts. The cheapest shirt to buy is an untreated one. But if laundering costs are also considered, it is a different matter. If the housewife counts the time she spends starching and ironing the shirt, and figures her time is worth $1.00 an hour, it will cost her $16 to launder the untreated shirt before it is thrown away. The shirt now has a total cost of $19.95. On the other hand, she will spend only about $2 of her time, laundering a wash-wear shirt that originally cost $4 or $5. So, if time is money to the housewife, the wash-wear shirt will look like a bargain to her.

AGRICULTURAL OIL PRODUCTS AND DERIVATIVES

In addition to the evaluation of new cotton processes and products, there also has been an evaluation of new processes developed at the Southern Laboratory for producing new derivatives of cottonseed, rice, and tung. Some of these derivatives show promise as low-cost products of high quality.

Gossypol (53). A practical source of gossypol is cottonseed gums, which are obtained as a byproduct in the water washing of cottonseed oil processed from the seed by direct solvent extraction. The gossypol extraction process is shown in Figures 8 and 9. The gossypol is cleaved and separated from phosphatides in

FIGURE 8
PHASE I
FLOW SHEET FOR
RECOVERY OF GOSSYPOL-ACETIC ACID FROM COTTONSEED GUMS

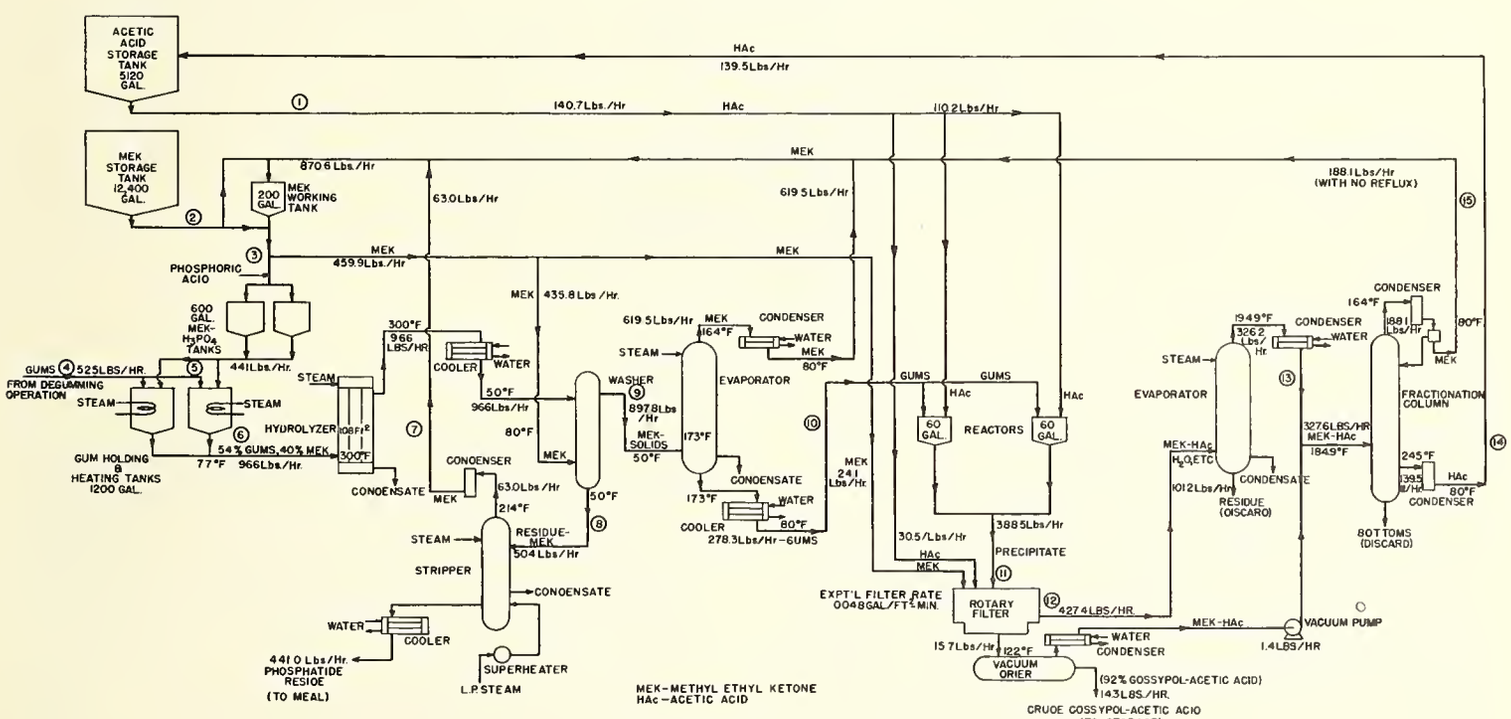
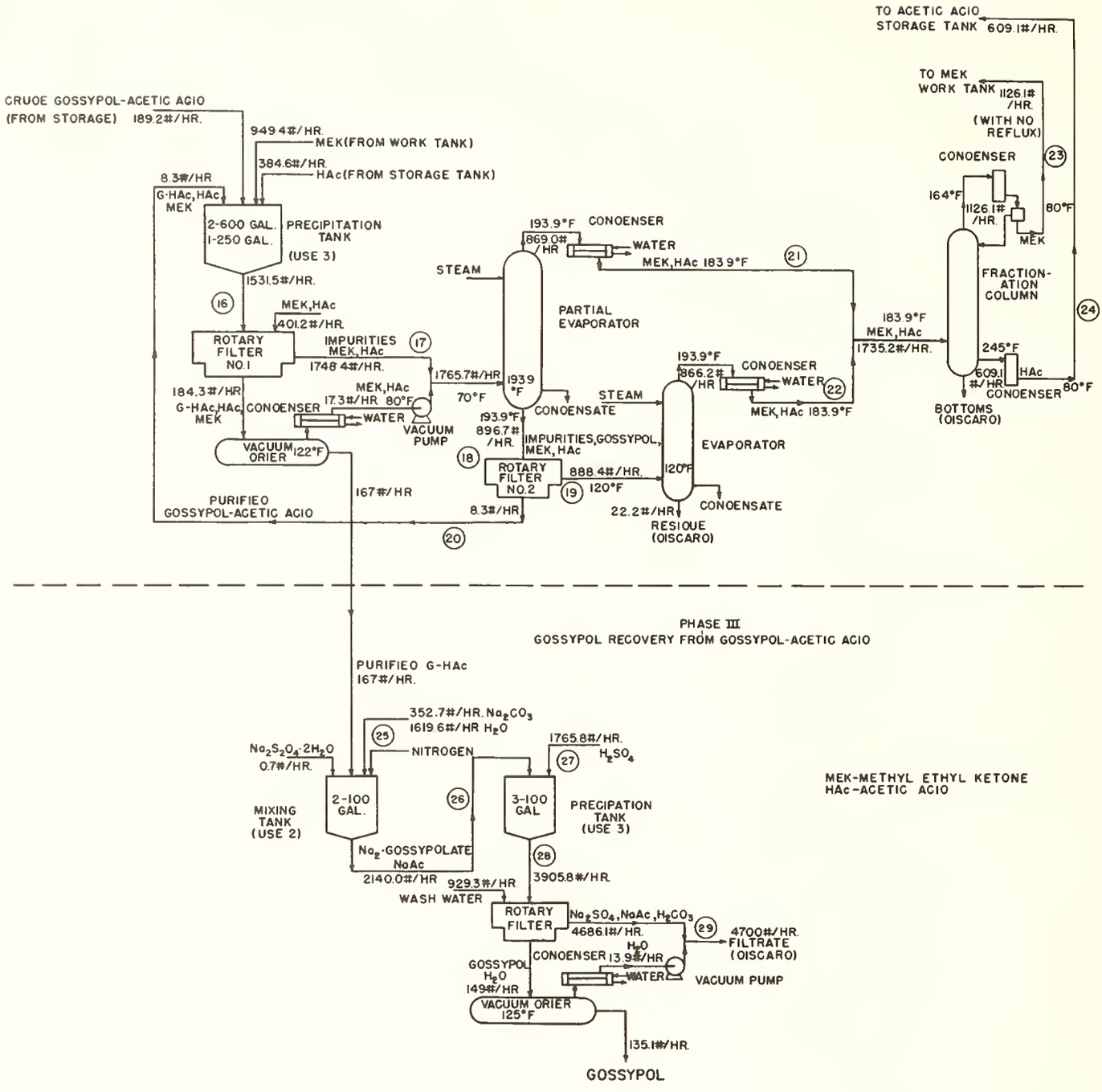


FIGURE 9

PHASE II
PURIFICATION OF GOSSYPOL-ACETIC ACID



the gums by mild acid hydrolysis in methyl ethyl ketone, in which both water and phosphatides have limited solubility. The gums are refluxed with methyl ethyl ketone containing either oxalic or phosphoric acids, using a gums to solvent ration of about 1:1. Upon cooling, the mixture separates into a supernatant MEK phase which contains most of the gossypol and a lower phosphatide—water phase. The lower phase is then washed with MEK to remove practically all of the gossypol. After concentration of the combined MEK decantate and washings by distillation, addition of glacial acetic acid to the concentrate allows isolation of gossypol as the crystalline acetic acid-additon compound. The crude gossypol-acetic acid is purified by two recrystallizations. Relatively pure crystalline gossypol is obtained from the pure gossypol-acetic acid complex by dispersing the complex in dilute aqueous sodium carbonate, then acidifying with a mineral acid. The estimated total manufacturing cost for producing 81,000 pounds of pure gossypol annually is $5.55 per pound of product. For producing 113,500 pounds of crude gossypol-acetic acid and 100,200 pounds of purified

gossypol-acetic acid annually, the estimated total manufacturing costs are $2.64 and $3.80 per pound of product, respectively (41).

It is readily apparent that gossypol and gossypol-acetic acid as produced are expensive chemicals and probably would have to be produced for specialized uses, such as pharmaceuticals and the like, in which the cost of these chemicals would not be prohibitive. Should product evaluation research now under way establish specific uses for gossypol and its intermediates, a demand for sizeable quantities of these materials might result.

Cocoa Butterlike Fat (66). A cocoa butterlike fat has been prepared on a pilot plant scale at the Southern Division. The process is illustrated in Figure 10 and consists of the interesterification of hydrogenated cottonseed oil and triolein for 30 minutes at 150° F. in the presence of sodium ethylate catalyst, followed by two successive fractional crystallizations from acetone—the first at room temperature to remove the predominantly saturated triglyceride fraction, and the second at 32° F. to produce the cocoa butterlike product. Using a crystallization time of 1 hour for each of two crystallizations, a preliminary cost of approximately 42 cents per pound has been estimated. Laboratory data indicate that comparable products can be obtained for crystallization times as low as one-half hour. It is believed that a substantial reduction in cost will result. Last year cocoa butter sold for about $1.00 per pound, and it has been reported that more candy makers are switching to cocoa substitutes nowadays. Many industry leaders believe the present upsurge in substitute usage could be the forerunner of an entirely new trend in chocolate making.

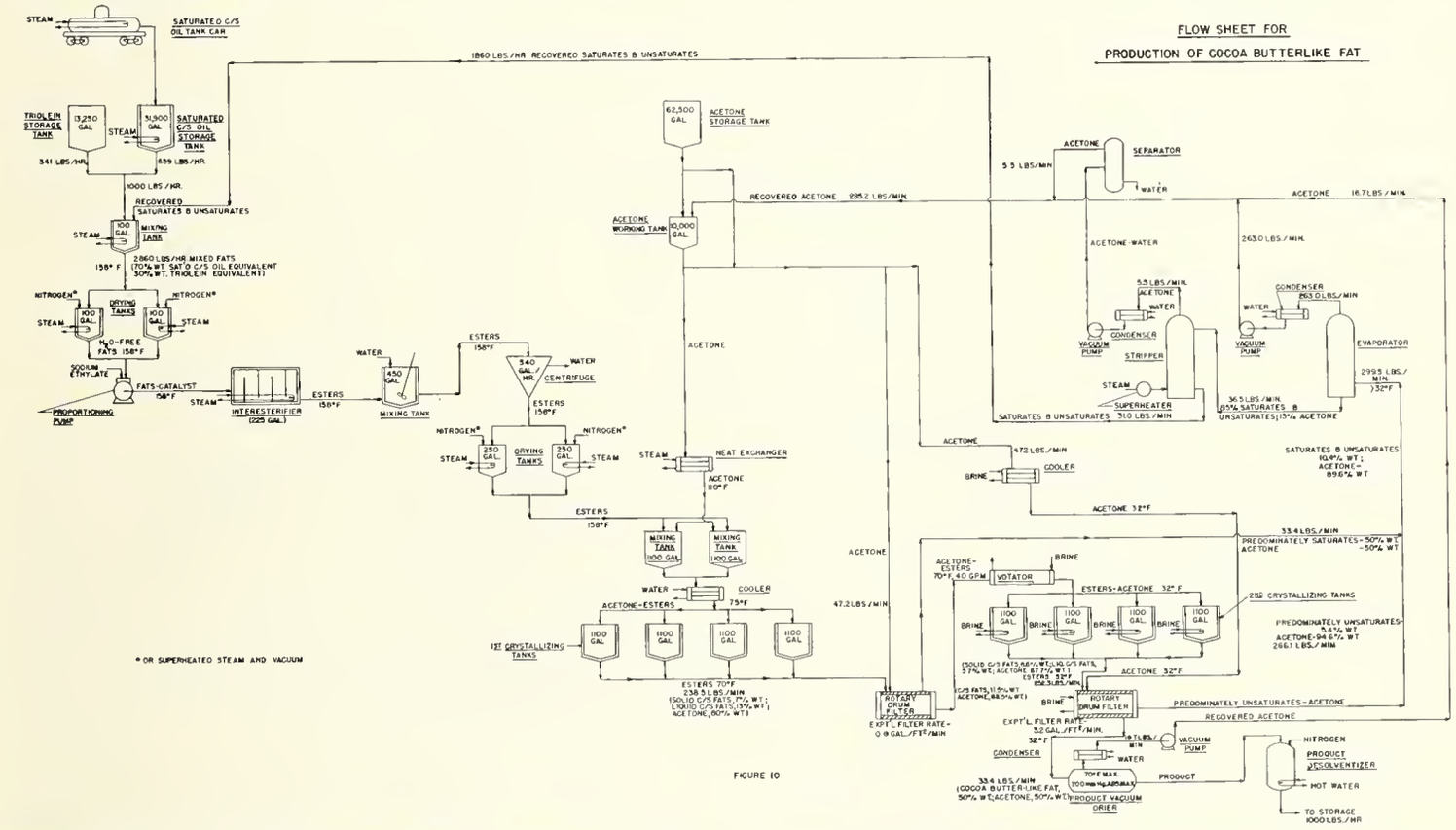
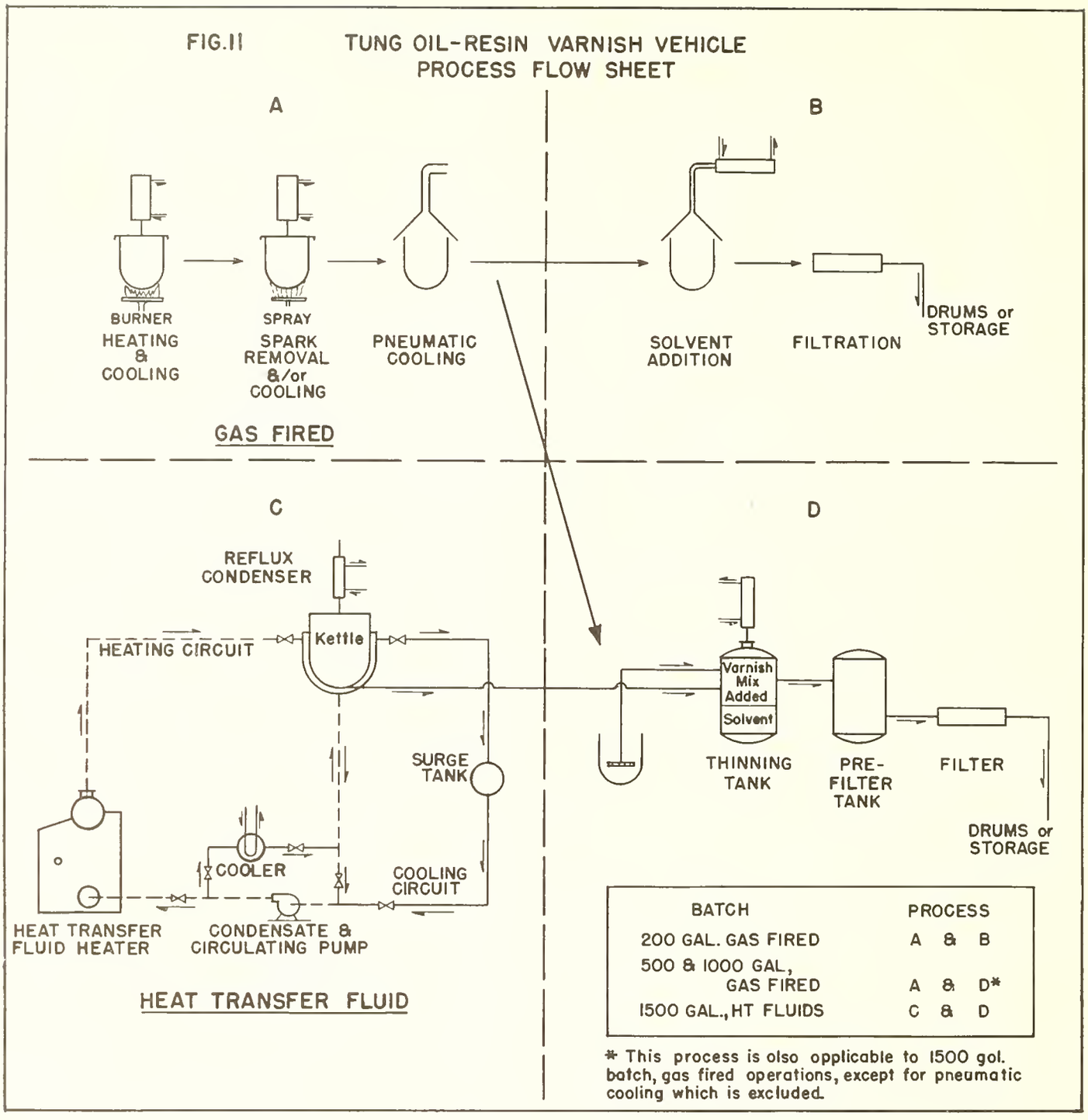


FIGURE 10

Tung Oil-Resin Varnish Vehicle (25). Tung oil-resin varnish vehicle is produced from tung oil and rosin by a process which prevents gelation. This low-cost general purpose varnish is being produced by several manufacturers and used as a floor sealer and finish coat. The process for producing 50 percent solids tung oil-resin varnish vehicle is diagrammed in Figure 11, and consists of heating a mixture of specified proportions of tung oil, zinc resinate, and maleic modified rosin ester, to a temperature of 530° F., gasproofing the mixture at 530° F. for at least 10 minutes, cooling to about 340° F., thinning with an equivalent weight of mineral spirits, and filtering. The retention of the vapors in contact with the mixture during heating, gasproofing, and initial cooling to 390° F. is necessary in order to avoid gelling of the mixture, if the cooking time exceeds 4-½ hours.



Costs for producing 50 percent solids tung oil-resin varnish vehicle of 15-gallon and 25-gallon oil lengths have been estimated to range from $1.27 per gallon at an annual production of 680,000 gallons, to $1.50 per gallon at an annual production of 10,000 gallons (17). It has been found that a combination of annual production requirements, total plant cost, and equipment preferences of the manufacturer would be the main considerations in selecting the size, type, and number of kettles; and that kettle type and size have little apparent effect on costs.

Additional costs for thinning the 50 percent solids mixture with an equal volume of varnish makers' and painters' naphtha for use as a floor sealer were estimated to be 12.6 to 26.7 cents per half-gallon of 50 percent solids mixture, resulting in costs of $0.76 to $1.02 per gallon of 25 percent solids mixture.

Filtration-Extraction (30, 37). This new simplified, versatile method of direct solvent extraction derives its name from separation of the oil in hexane solution (miscella) from extracted meal (marc), and countercurrent washing with hexane, both of which are carried out on a continuous, horizontal, rotary, vacuum filter. The process (37) is built around the unit opera-

tion of filtration, and consists of the preparation of the material by flaking (except for materials such as rice bran), cooking, and crisping; bringing the oil into almost complete solution in a mixing vessel during a short soaking period and then separating the oil from the meal by filtration and countercurrent washing. Oil and meal products are recovered by conventional methods.

The filtration-extraction process, a modified direct-solvent process, provides the smaller cottonseed crusher with a more efficient and practicable processing method, resulting in lower operating costs and increased yields while producing high quality oil and meal. At the Mississippi Cottonseed Products Co. Oil Mill in Greenwood, Miss., operating profits have increased more than $750 per day since conversion from hydraulic pressing to filtration-extraction in 1954 (2). A second filtration-extraction plant was installed by that company in 1957, in Hollandale, Miss. Cottonseed and soybeans are being processed in both plants. Another filtration-extraction plant was installed in 1957 in Santiago, Chile, by La Cia Productora Nacional De Aceites, and rice bran and sunflower seed have been successfully processed there.

Cost studies at the Southern Utilization Research and Development Division (21, 47) show that investment costs for hypothetical cottonseed filtration-extraction mills are less than those for comparable mills of direct- and prepress-solvent types. Increased profits calculated show that conversion to filtration-extraction can be paid for in a few years.

At the Southern Laboratory, in addition to cottonseed studies, rice bran, flaxseed, peanuts, milo germ, sesame seed, and castor beans have been studied in bench-scale tests (32, 51, 52). Rice bran, flaxseed, and milo germ have been handled in the continuous, filtration-extraction pilot plant (33, 50). The simultaneous recovery of oil and wax from rice bran was developed on a bench scale, and a cost study revealed that additional investment and operating costs needed to produce rice wax are reasonable, and should considerably increase the income of the rice oil producer (50).

SUMMARY

New low-cost processes have been developed for converting cotton into textile products having improved flame-, heat-, mildew-, rot-, soil-, weather-, and wrinkle-resistance, water repellency, increased breaking strength and elongation, dyeability, solubility, reactivity, ion-exchange, and, other improved properties. A number of these processes can be accomplished in conventional textile finishing equipment and are particularly suited for intermittent production in equipment already available at finishing plants.

It is apparent from Table 1, which shows the various costs calculated, that these chemical processings of cotton can be inexpensive. Partial acetylation, carboxymethylation, APO-THPC resin finishing, THPC-Methylolmelamine resin finishing, and wash-wear finishing have been adopted commercially. The formic acid colloid process is approaching commercialization.

New derivatives of cottonseed, rice, and tung show promise as low-cost products of high quality. These are cocoa butterlike fat, tung oil-resin varnish vehicle, cottonseed oil and meal, and rice bran wax from filtration-extraction. Of these, filtration-extracted oil and meal, and tung oil-resin varnish vehicle are being produced commercially.

Table 1. *Chemical Modification of Cotton Fabric Rates and Costs for Continuous Processing*

Process	Rate Yards/Min.	Cost Cents/lb. product
Aminization	50	20.4
APO	120	8.2 [1]
APO-THPC	120	11.3 [1 2]
Carbamoylethylation	120	16.4
Carboxymethylation	50	9.9
Cyanoethylation	50	12.8 [3]
Formic acid colloid	120	14.9 - 10.8
Hydroxyethylation [4]	50	16.3
Partial acetylation	12	16.7
Phosphonomethylation	50	14.7
THPC-Methylolmelamine	120	15.0 [2]

[1] Based on projected APO price of 30 cents/lb.
[2] Based on projected THPC price of 70 cents/lb.
[3] Based on projected AN price of 17 cents/lb.
[4] Semicontinuous operations.

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